The MAKING and FEEDING of SILAGE

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SILAGE OCCUPIES an important place in the feeding of livestock. It may be a major source of all nutrients or, when properly made, it may serve primarily as a source of carotene or other vitamins or minerals. Crops for silage are rarely a total failure as neither drought nor excessive rains prevent the making of at least part of a crop into silage. Some crops can be utilized more efficiently as silage than as dry forage because in the form of silage the entire crop is edible. Apparently, any forage crop can be made into silage, but where corn can be grown successfully it is the outstanding silage crop.

Good quality in the silage depends on cutting the crop at the right stage of maturity, chopping it fine, thoroughly excluding the air, and obtaining enough but not too much moisture in the cut material. When silage is rightly put into and carefully removed from the silo, there is no loss from spoiling except on the surface.

Silage is a good feed for dairy cattle of all kinds and for beef cattle, from breeding cow to fattening steer. Sheep like it, and it is well suited to their needs. Horses and mules may be fed limited quantities of wholesome silage with satisfactory results.

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Contents

SILOS, SILAGE CROPS, AND THE MAKING OF SILAGE

SILAGE is moist forage that has been stored in the absence of air. The preservation of feed in this way is not a new process; it is stated that centuries ago green crops in northern Europe were placed in silos. However, it was not until about the middle of the nineteenth century that silage making began to be well known in Europe. In the United States the construction of the first silo has been credited to F. Morris, of Maryland, in 1876.

In recent years some 40 million tons of silage has been made annually in this country, with a value, at a conservative estimate, of upward of 150 million dollars. At present, probably about 98 percent of the silage is made from corn or sorghums and about 2 percent from small grains or hay crops. Silos are most numerous in those regions where corn or sorghum thrives or where the production of high-quality hay is uncertain or where dairying is an important industry. This is not because silage is considered a poor feed for other kinds of livestock but because dairy cows must have a high-quality feed and be able to get it without too much effort and without too much exposure to severe weather.

The advantages and disadvantages of silage, as compared with other forage, may be stated as follows:

Advantages: Silage saves feed that would be inedible in the dry state or would be damaged by rains. It is quite palatable and has a high content of carotene. It clears the ground early and completely for another crop. Storing a crop as silage instead of as hay eliminates the hazard of fire.

[1] This publication is a revision of an edition prepared by these writers in 1935 and of former editions prepared by T. E. Woodward, Bureau of Dairy Industry, and J. B. McNulty, formerly of the Bureau of Dairy Industry; and George M. Rommel, E. W. Sheets, and F. R. Marshall, formerly of the Bureau of Animal Industry.

Of the current edition, T. E. Woodward prepared the sections Silos, Silage Crops, and the Making of Silage, Feeding Value of Silage, and Silage for Dairy Cattle, W. H. Black the section Silage for Beef Cattle, D. A. Spencer the section Silage for Sheep, and J. O. Williams the section Silage for Horses and Mules.

Disadvantages: Silage requires additional outlay for buildings, equipment, and power. It concentrates the labor of harvesting into a few days. Most silage has a low content of minerals and protein and is not suitable for use as the sole ration. If it is fed in place of legume hay in the ration, more expense must be incurred for high-protein feed.

KINDS OF SILOS

Silage is made in stacks and in structures of various kinds. Stacks are used extensively in New Zealand and Holland for siloing grass and to some extent in this country for siloing cannery refuse. Success with this method depends upon plenty of moisture in the crop, thorough packing, and in the case of hay crops upon a covering to exclude air as well as to provide weight.

Common types of structures are the trench silos, which predominate in the South, Southwest, and the Great Plains, and the tower silos built of wood, concrete, tile, brick, or stone. The latter predominate in the North and East. Other types are the pit silos of northern Europe, the pit stacks of the Northwest, the box silos developed in South Carolina, and the slatted-fence silos. All these preserve silage effectively if the air is excluded and adequate drainage provided for any excess liquid that may accumulate by seepage from the soil or by expression of juice. The quantity of spoiled silage varies directly with the surface exposed to the air. This accounts for the heavy loss in stacks, especially small ones, and in shallow silos.

CAPACITIES OF SILOS AND THE WEIGHT OF SILAGE

The weight of material that can be put in a silo depends upon the moisture content of the crop, the depth and diameter of the silo, the rapidity of filling, the length of cut, and the character of the crop. Corn with a normal content of moisture chopped in ¼- to ⅜-inch lengths and put in a silo 14 feet in diameter by 40 feet in height at the rate of about 30 to 40 tons a day will contain on an average about 13 pounds of dry matter to the cubic foot and, when taken out after several months, will contain about 13.5 pounds of dry matter to the cubic foot. The average weight, therefore, of a cubic foot of such silage immediately after filling would be about 46 or 47 pounds if the moisture content was 72 percent; and the average weight after several months, assuming the moisture content to be the same as in the freshly chopped material, would be about 48 pounds to the cubic foot. The reason that the silage after several months weighs only a little more per cubic foot than it did when filled in is that the increase in weight from the reduction in volume by settling is partly offset by the losses from evaporation and fermentation and also sometimes from expression of juice. The dry matter in a cubic foot of grass or legume silage is usually about the same as in a cubic foot of corn silage. Corn silage (with a normal moisture content) packed in a trench silo 7 feet deep, is said to weigh from 35 to 40 pounds to the cubic foot.

Table 1 shows the sizes of silos suitable for herds of different sizes and fed at different rates.

TABLE 1.—*Size of silo required for different sized herds when fed at various rates*

Number of animals	Quantity fed per animal daily	For a winter feeding period of 200 days		For a summer feeding period of 100 days	
		Total amount needed	Diameter and height of silo (inside measurements)	Total amount needed	Diameter and height of silo (inside measurements)
	Pounds	*Tons*	*Feet*	*Tons*	*Feet*
5	30	15	8 by 18		
5	40	20	8 by 22		
5	50	25	8 by 26		
10	20	20	8 by 22	10	(1)
10	30	30	10 by 22	15	[2] 8 by 18
10	40	40	10 by 28	20	[2] 8 by 22
10	50	50	10 by 32 or 12 by 24	25	8 by 26
20	20	40	10 by 28	20	[2] 8 by 22
20	30	60	12 by 28	30	[2] 10 by 22
20	40	80	12 by 36 or 14 by 28	40	10 by 28
20	50	100	14 by 34	50	10 by 32 or 12 by 24
30	20	60	12 by 28	30	[2] 10 by 22
30	30	90	14 by 30	45	10 by 30
30	40	120	14 by 40 or 16 by 32	60	12 by 28
30	50	150	16 by 38	75	12 by 34
40	20	80	12 by 36 or 14 by 28	40	10 by 28
40	30	120	14 by 40 or 16 by 32	60	12 by 28
40	40	160	16 by 40	80	12 by 36 or 14 by 28
40	50	200	16 by 48 or 18 by 40	100	14 by 34
50	20	100	14 by 34	50	10 by 32 or 12 by 24
50	30	150	16 by 38	75	12 by 34
50	40	200	16 by 48 or 18 by 40	100	14 by 34
50	50	250	18 by 48	125	14 by 40 or 16 by 32

[1] A silo that would hold only 10 tons or less would be too small to be practicable.
[2] Too shallow to permit 3 inches to be removed daily. Removal of less than 3 inches daily is not practicable for summer feeding.

CHANGES THAT TAKE PLACE IN THE SILO

When a crop is placed in the silo the temperature rises until all the air in the interstices of the silage is exhausted. The extent of the rise is directly proportional to the quantity of air present. Coarse chopping and poor packing favor the development of high temperatures. Ordinarily silage should not reach a temperature above 100° F. Temperatures higher than this indicate the presence of too much air. The maximum temperature is usually reached within a week, after which the silage cools slowly and steadily. If a high temperature persists, it is evidence that air is penetrating from the top or sides of the silo. If the high temperatures continue long enough the silage will eventually become moldy. Apparently the high temperature is not in itself destructive to the quality of the silage, but it is an evidence of a high rate of oxidation, which increases the losses of feed constituents and impairs the quality of the silage.

The plant cells of fresh green crops continue to respire after chopping, that is, to take in oxygen from the air and to give off carbon dioxide. Fermentation starts quickly, and this also uses oxygen. The action of these two agencies soon results in the replacement of the oxygen in the

air with carbon dioxide. When this is accomplished the silage will keep indefinitely without molding or rotting, provided no more air gains access to it.

The principal changes that take place during fermentation are: (1) Some of the nitrogen-free extract (sugars, starches, etc.) is converted to lactic, acetic, and other acids by the action of yeasts and bacteria; (2) some of the protein breaks down into simpler and perhaps less valuable nitrogen compounds; and (3) there is loss of carotene, which may be much or little, depending upon the amount of air present for oxidation. The ether extract (fat) is usually increased, because some substances have been developed which are extracted by the ether along with the fat when analyzed chemically. This probably does not mean any increase in the actual fat. The largest loss of feed constituents is in the sugars and starches.

The development of some acid during fermentation is inevitable, and although this has little or no protective action against molding or rotting, it may have a pronounced effect on the quality of the silage as judged by its odor and palatability. High moisture and low acidity occurring simultaneously will favor the formation of butyric acid, indicated by an objectionable and clinging odor, and will be accompanied by some breakdown and loss of protein. Silage with high moisture and high acidity, or low moisture and low acidity, or low moisture and high acidity will not have a bad smell.

Crops with a low content of protein and calcium, such as corn, sorghums, and small cereal grains, when siloed alone or with not more than an equal weight of legumes, will develop enough acid to make good silage. The addition of lactic acid cultures or the acid itself or any material from which acids are formed is of no apparent value in making silage from these crops, and wilting to reduce the content of moisture is generally not advantageous when all things are considered. Crops with a high content of protein and calcium, such as the legumes and immature grasses, should have molasses or acid added or should be wilted. Grasses that are harvested at the usual hay-making stage will need no special treatment, provided they are not wet with dew or rain. If they are wet, it would be safer either to add molasses or to let the excess moisture evaporate.

The only actual spoilage that cannot be avoided in the silo is that which occurs at the top of the silage. In a silo 14 feet in diameter this spoilage will amount to about 1½ to 2 tons 3 months after filling. With trench silos even this spoilage is sometimes avoided. Tight sides and careful sealing around the doors of tower silos should prevent any other spoilage.

The losses through fermentation may be considerable or almost negligible, depending largely on the effectiveness with which the air has been forced out and thereafter excluded. Over a 3- to 6-month storage period one may reasonably expect a loss of not less than 10 percent of the dry matter. There is evidence that the losses in summer exceed those in winter, also that silage stored for long periods loses more dry matter than silage stored for short periods. It appears that there is no particular difference in the effectiveness with which various crops are preserved in the silo, provided proper methods have been followed in making the silage.

CROPS SUITABLE FOR SILAGE

Any green forage crop can be made into silage that will keep in good condition without an excessive loss of food nutrients. Few feeds are improved either in palatability or in nutritive value by undergoing fermentation in the silo; on the other hand, none appear to be affected detrimentally to any marked extent. Very coarse or weedy crops when made into silage may be completely edible, whereas if such feed is made into dry fodder or hay much of it would be rejected by the cattle or other livestock. The spines or awns on certain plants may be rendered harmless through siloing. For example, in the far West forage containing dry foxtail, the awns of which are injurious to animals, may be made into a safe and useful feed by converting it into silage. As a rule, if a forage is palatable and nutritious when it is put

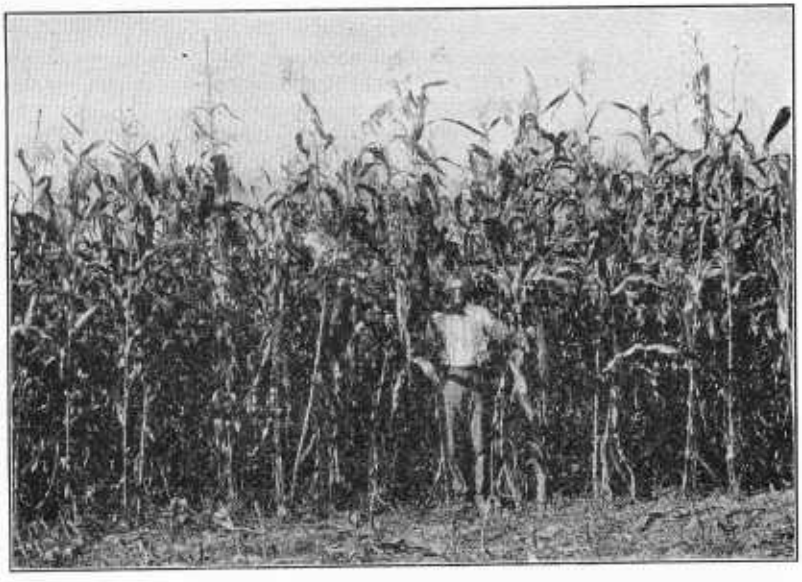

FIGURE 1.—Well-eared corn makes silage of the best quality.

into the silo, it will be palatable and nutritious when it is taken out; if it is a poor feed when put into the silo, it will be a poor feed when taken out.

Corn

Corn is the common silage crop wherever it can be grown successfully (fig. 1). Silage made from corn is very palatable and will keep in good condition for years. Throughout a considerable portion of the United States more food material can be obtained from an acre of corn as silage than from an acre of any other crop. Experiments at the Missouri Agricultural Experiment Station have shown that corn, when siloed, loses 4.01 percent of its dry matter as compared with 15.12 percent when cut for fodder and cured in the field. Moreover, there is less waste in feeding silage than in feeding fodder, since good silage properly fed is practically all consumed. For wintering calves 1 acre of corn silage has been shown to be equal to 1.63 acres of dry ground corn fodder, in experiments on feeding beef cattle at the Kansas

Agricultural Experiment Station. Corn can be put into the silo at a cost as low as that of shocking, husking, grinding, and shredding.

Varieties to Plant

As there is a steady increase in all nutrients of a corn crop up to maturity, it is best to plant a variety of corn that will mature sufficiently for silage before frost. Since the corn does not need to be so mature for silage as for grain, it is possible to use a later maturing variety and thus obtain a greater yield than would be obtained from the earlier maturing varieties ordinarily planted for grain. In a 5-year test made at the Ohio Agricultural Experiment Station reported in 1923, it was found that the early maturing corn yielded on an average 10.31 tons of silage per acre, whereas the late maturing corn yielded 11.97 tons. There appears to be little if any advantage in using a variety which produces foliage and stalk at the expense of grain, as the ears contain the most valuable part of the food constituents. Ordinarily the variety of corn that will produce the most grain to the acre is the best to use for silage. The more grain there is in the silage the more nutritious the silage will be and the greater will be the saving of concentrated feed used to supplement the silage.

Methods of Planting

Work done at the Illinois Agricultural Experiment Station as far back as 1890 showed that thick planting results in greater tonnage and in more stalk and foliage in proportion to the ears than does thin planting. When the corn is planted less than about 12 inches apart in rows from 40 to 44 inches apart on good land, the total yield of ears is decreased and the proportion of poor ears to good ears is increased. Planting more than about 12 inches apart on good land increases the proportion of good to poor ears but decreases the total weight of ears. It is thought best to space the planting so as to obtain the greatest total yield of ears. On good land this will be about 12 inches; on poorer land, possibly as much as 18 inches. On weedy land it is better to plant in hills so that the corn can be cultivated both ways, in which case the planting may vary from two to three kernels in a hill to three or four, depending on the fertility of the soil. Weeds will lower the yield of corn, but unless present in great numbers do not noticeably affect the quality of the silage and therefore can be cut along with the corn and put into the silo.

Yield

From 4 to 20 tons of silage can be obtained from an acre of corn. The average for the United States in seasons of normal rainfall is about 7 tons an acre. A 50-bushel crop of corn yields from 8 to 12 tons of silage an acre, depending on the amount of leaves and stalks that accompany the ears and on the stage of maturity at which it is siloed. The quantity of silage that may be expected per acre is often roughly estimated at 1 ton for each 5 bushels of shelled corn. Southern varieties of corn as a rule have a larger proportion of stalks and leaves than northern-grown varieties.

Time to Harvest

Ordinarily corn should be harvested for the silo about 10 days before it would be cut for shocking. The most advanced stage of maturity at which corn can be harvested and still make silage of the highest quality from it is when about 90 percent of the kernels are dented and 75 percent or more of the kernels are hardened so that no milk can be squeezed out. At this time the lower leaves on the stalk are turning brown and the green corn fodder contains about 70 percent of moisture. The corn can rarely all be put in the silo at the exact stage of maturity desired. It is generally better to harvest the corn at a stage that is less mature rather than more mature than that described. Silage made from ripe corn lacks aroma and palatability and is more difficult to pack so as to exclude air.

Table 2, which is based on data taken from the eighth annual report of the New York State Agricultural Experiment Station, shows the steady increase in the yield of food nutrients per acre up to the time the corn is ripe. For this reason the corn plant should be allowed to mature as much as possible and still be in condition to make a high-quality silage. Probably the moisture content should not be much below 70 percent.

TABLE 2.—*Chemical changes during growth of corn plant*

Stage of growth and date	Yield per acre	Composition by weight						
		Water	Dry matter	Ash	Albuminoids	Crude fiber	Nitrogen-free extract	Fat
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Tasseled, July 30	18,045	16,426	1,619	138.91	239.77	514.19	653.91	72.20
Silked, Aug. 9	25,745	22,666	3,078	201.30	436.76	872.93	1,399.26	167.75
Milk, Aug. 21	32,600	27,957	4,643	232.15	748.69	1,261.97	2,441.29	228.90
Glazed, Sept. 7	32,295	25,093	7,202	302.48	643.86	1,755.85	4,239.82	259.99
Ripe, Sept. 23	28,460	20,542	7,918	364.23	677.78	1,734.04	4,827.60	314.34

Immature and Frosted Corn

When weather conditions, such as hail, drought, or frost, prevent the maturing of corn for the silo, it may be cut while still immature and produce a fair grade of silage. A good practice is to mix such corn with some that is more mature. Silage from immature corn is sourer than that from mature corn and more laxative when fed in large quantities. Trouble from this source can be avoided by feeding smaller quantities.

Frosted corn dries out very quickly, and many leaves are lost in handling. The corn may also be so dry that it does not pack well. Frosted corn should be cut at once, in order to prevent excessive drying out. If this is done, the stalks will contain sufficient moisture for satisfactory silage. Water may be added to facilitate packing, but this will not be necessary if the corn is chopped very fine and is well distributed in the silo and the walls and doors of the silo are tight. In any event, the top should be well wetted and thoroughly tramped. The frosting of the corn causes only a small decrease in the usual feed nutrients, the greatest part being due to the loss of

leaves in handling. Frosting, however, does reduce the carotene content of the corn and of the resulting silage to a marked extent.

Dry Corn Fodder

Because of insufficient silo capacity, it is sometimes necessary to shock the corn; also it is often desired to refill the silos after the silage has been fed out. Dry corn fodder may be siloed successfully, so far as the prevention of spoilage is concerned, but enough water must be added to make it pack well in the silo or else it must be chopped very fine. If the corn fodder has been in the shock for as much as a month, the safest plan is to add water. This may be done by allowing a stream from a hose to flow into the blower or the top of the blower pipe while filling. Corn-fodder silage is not so palatable or so good as silage made when the corn is at the proper stage. It also lacks the aroma of good corn silage. Owing to the large quantity of water required, siloing dry corn fodder is advisable only on farms having a convenient and adequate water system.

Dry corn stover likewise can be made into silage by the same method. It lacks flavor and palatability and is low in feeding value. It is doubtful whether the making of such silage is an economical practice.

Sorghums

The sorgos or so-called saccharine sorghums, such as Amber, Orange, and Atlas "cane," and the nonsaccharine sorghums, such as kafir, feterita, milo, hegari, and Sudan grass, are suitable for silage. Sorghums are more dependable and yield more in those regions of the South and West where the rainfall is too light or irregular or the soil or climate is not so well adapted to the growth of corn. For successful silage it is important that sorgo be harvested when the seed has become hard. If harvested earlier, a silage with a high acid content is produced. Sorghum silage is likely to have a higher content of water and less grain, and for these reasons does not ordinarily have as high feeding value as corn silage. Some investigations have shown also that the proportion of seed that escapes digestion is greater with sorghum than with corn. A mixture of corn and sorghum has proved to be satisfactory in some localities where the rainfall is so variable as to make the corn crop uncertain.

Legumes

All legumes, including alfalfa, clovers, cowpeas, soybeans, lespedezas, and vetches, can be made into silage successfully. Those that are good feeds in the green state or when made into hay will likewise be good feeds when made into silage. Also, the stage of maturity for harvesting to make the best hay results in the best silage. If a crop is too mature to make a leafy hay and one that will be eaten without waste, it can usually be made into a silage that conserves more of the leaves and will be consumed with practically no waste. There is no special superiority, however, in legume silage over the hay in feeding value if the hay is harvested at the proper stage of maturity and is so cured as to retain most of its leaves and green color. Also, the labor required for making silage exceeds that required for making hay. For these reasons, the making of legume silage is not advisable under con-

ditions that permit the making of good hay with certainty. When the weather conditions, as is generally the case over a considerable portion of the country, are likely to be unfavorable for making hay, the conversion of the crop into silage is a very satisfactory alternative.

The low fermentable sugar content and the high protein and calcium content of legumes favor the development of undesirable types of bacteria so that special precautions must be taken in making legume silage or it will be unsatisfactory as to odor, palatability, and feeding value. There are three ways of making a good-quality legume silage. In each of these the usual precautions of fine chopping, tight packing, adequate covering, and suitable drainage are essential. The special features of the different methods are as follows: (1) One way is to fill the silo in shallow layers, each layer being allowed to heat to about 140° F. before the next layer is added. This method is too slow to be satisfactory.

(2) Another way is to add either acids or sugars from which acids are formed. Hydrochloric and sulphuric acids give silage of good appearance and odor but will seriously impair the palatability of the silage unless used in small amounts which help the fermentation to take the proper course without markedly affecting the palatability. Liquid phosphoric acid in amounts commonly recommended, 16 pounds to the ton, does not assure a good quality of silage under all conditions. Very moist legumes may require 24 pounds. Silage made with phosphoric acid is palatable, corrects the ration for any deficiency in phosphorus, and has a high salvage value as fertilizer if the manure is saved and applied to the soil. The effect of long-continued feeding of such silage on the well-being of livestock has not been established. Finely ground limestone should be fed with all acid-treated silages at the rate of one ounce of limestone to each 15 to 20 pounds of silage.

Of the so-called preservatives, molasses is preferred to any of the acids because it is not harmful in any way, and it improves the palatability, especially that of high-moisture silage. The objections most frequently stated are the cost of the molasses and the excessive leakage of juice from the silos. Just what products besides acid are formed from the molasses in the silo and the nutritive value of these products are unknown; so it is impossible to say how much molasses adds to the value of legume silages, beyond improving the odor and palatability in the case of high-moisture silage.

(3) The cheapest way to make a good-quality legume silage is to see that the moisture content of the silage is somewhere between 50 and 68 percent before filling. Why low-moisture silage is more palatable and higher in feeding value than high-moisture silage has never been adequately explained. However, a large amount of work shows unmistakably that reduction of the moisture (when necessary) to the proper content by wilting will improve the feeding value of the silage as much or more than the addition of acids or molasses to the high-moisture legume. Furthermore, the expense of a preservative is saved, and the nuisance and destructive action of silage juices leaking from the silo are avoided. More detailed directions for making such silage are given below.

If the legumes are harvested during a dry spell of weather, put them in as soon as possible after mowing. If they are not harvested during a dry spell, allow them to wilt for 2 hours on a good drying day, or longer on a poor drying day. When the crops are chopped they

should not be wet with rain nor with much dew. Set the silage cutter to chop in ¼-inch lengths. If possible, do not allow more than 1 day to elapse while filling. Some of the top may spoil if exposed for more than 48 hours. Top off the silo with 2 or 3 feet of the heaviest, greenest material that can be obtained. This is for the purpose of providing an air seal for the material underneath. Level off and tramp the top thoroughly. Each week until the silo is opened for feeding fill any spaces that may have opened at the top between the silage and the wall and tramp well next to the wall. Should any juice be squeezed out of the silage, as evidenced by leakage from the silo, see that it has the opportunity to escape from the silo readily, as waterlogged silage is likely to be of poor quality. The aim is to have the moisture content of the crop just low enough to avoid leakage of juice from the silo, but if the crop is a little drier it can still be siloed successfully.

Mixtures of Legumes and Other Crops

Field peas and oats are much used in the Northwest as a silage crop in place of corn, and while there appears to be no trouble in making silage of good quality a number of experiments show it to be less valuable, pound for pound, than corn silage. Vetch and wheat, vetch and oats, or vetch and rye are other combinations of a legume with a small grain that are used to some extent as silage.

Soybeans have been grown with corn, Sudan grass, or millet primarily to increase the protein content of the silage. Corn and soybeans grown together may not yield more heavily than corn alone, but the silage is improved in protein and mineral matter. Drilling gives larger yields than checking; three beans to one kernel of corn is about the right proportion. If weeds are a serious problem with drilled corn, it is not advisable to plant soybeans with the corn and thus prevent cross cultivation. There is usually no difficulty in harvesting the corn and soybeans with a corn binder. Mixtures of soybeans with Sudan grass or millet should be harvested at the stage of maturity that is best for hay. They make very satisfactory silages, and no special precautions are needed for making silage of them.

Red clover is commonly grown along with grasses, as timothy and redtop, for hay, but the mixture may be put in the silo if the weather is unsuitable for curing hay. If the clover predominates the methods to use are described under making legume silage, and if the grass predominates those for making silage from the grasses are advisable.

Grasses

Very good silage can be made from the grasses or mixtures of grasses and clovers that are ordinarily used for pasturage or hay. In certain other countries such silage is made rather extensively. The crop should be chopped rather than put into the silo whole. It should be low enough in moisture either naturally or by wilting so that there will be little or no leakage of juices from the silo. The silo should have a drain that will remain open to let any free juice flow away in case the material is too wet. Waterlogged silage from any crop is likely to be of poor quality. Immature grasses, if wilted, will make a better quality of silage than mature grasses, just as such grasses will make a better quality of hay. Until investigations show definitely that there

is no need for the addition of acids or molasses to immature grasses, it would be advisable to use about 40 pounds of molasses to the ton if the moisture content is high. No acid or molasses is necessary if the moisture content of immature grasses is below 70 percent (low enough to avoid leakage from the silo); nor is such addition necessary with grass harvested at the usual hay-making stage unless the crop is wet with dew or rain.

If properly made, grass silage will be very palatable and nutritious and possess an agreeable odor. Furthermore, it will have a very high content of carotene. Fine cutting, firm packing, and a moisture content of about 70 percent or less are the conditions essential to making the best grade of grass silage. Surplus spring pasturage under some conditions may be converted into silage advantageously to be fed later in the summer or the following winter. Experiments indicate that silage made from immature grasses will be eaten in as great quantities as similar grasses will be grazed; also, that the butter from cows fed grass silage will have much the same color as the butter from cows grazing the green grass.

The yield of silage to be obtained from a hay crop can be roughly estimated as three times as much as hay. That is to say a crop that will yield 1½ tons of hay will make 4½ tons of silage. The yields of Kentucky bluegrass are likely to be low. If one expects to make a practice of siloing grasses, he should raise timothy, orchard grass, or some other grass that yields more heavily than Kentucky bluegrass.

Pea Vines

The vines from pea-canning factories are commonly preserved for feed in the form of silage. In some cases these vines are put in the ordinary type of tower silo, but more often they are put in large stacks. The spoilage of the pea vines exposed to the air in stacks is considerable—being rarely less than 8 or 10 inches on the sides and 16 to 20 on the top. Provision should be made for the juice pressed out of the pea vines to flow away rather than to accumulate at the bottom of the stack. In sections where pea-vine silage is used it is considered to be worth one-third as much as alfalfa hay and only a little less than corn silage. Such silage is necessarily very moist and is likely to have a strong odor. Probably the addition of molasses would be helpful in making the odor more acceptable, although there have been no investigations reported on such a treatment. It is said that the milk is not tainted if the silage is fed after milking and the air of the milking stable is free from silage odors.

Corn-Cannery Refuse

In the canning of sweet corn the husks, cobs, shanks, and a small proportion of the kernels constitute the refuse and make up from 1,100 to 1,400 pounds to the ton of snapped corn delivered to the cannery. This is preserved for feed by putting it in stacks in the same way as pea vines from canneries or in silos of the usual type. In stacks there is considerable waste through spoilage, mainly because so much surface is exposed to the air. Chopping the refuse before it is put in the silo permits more thorough packing and lessens the waste in feeding. Corn-cannery silage has a feeding value estimated at about two-thirds that of normal corn silage.

Small Grains

Wheat, barley, and oats that are to be used for silage should be harvested when the kernel is in the milk or soft-dough stage. No special treatment is necessary except to cut the material fine and pack it firmly in the silo. Rye harvested when the grain is in the milk is likely to make an unpalatable silage, just as it will make an unpalatable hay. It is better to harvest the rye earlier, say when the first heads are emerging. In those regions of the United States where small grain can be harvested for silage before the first of June, it can be followed with another silage crop, so that the silo does double duty and two crops are obtained a year from the same land.

Beet Tops

If properly handled, beet tops and crowns can be made into silage of fair quality. The tops should be run through the cutter and put into the silo promptly after the beets are topped. In gathering the tops from the field care should be taken to have them free from dirt, as it damages the silage. Cut straw should be placed in the bottom of the silo to absorb excess moisture, and as fast as the tops are cut straw should be mixed with them. Salt sprinkled over the contents every few inches of depth is said to increase the palatability of the silage. Other coarse roughage, such as corn or cane stover, can be used in place of straw. Water should not be added to the silage. Beet top silage can be assumed to have a value roughly one-half that of corn silage.

Sunflowers

Sunflowers are used to some extent in the West and Northwest, where the weather is too cold and the season too short for the best growth of corn. There seems to be a universal agreement among investigators that in some localities sunflowers yield a much greater tonnage than corn. As high as 29.75 tons to the acre has been reported by the experiment station at Huntley, Mont. At that station it was likewise found that when planted in rows 20 inches apart the sunflowers gave greater yields than when planted farther apart. The plants were about 10 inches apart in the rows, and 15 pounds of seed was used to the acre. Unless harvested soon after they come into bloom and before the seeds are developed, the silage will be unpalatable. Sunflowers are not so easily handled as corn, on account of their stiff, brittle stalks, and because the heads tend to clog the feeding rolls of the silage cutter. The spiny growth on the stalks also makes them disagreeable to handle.

A composite of all feeding experiments indicates that sunflower silage is neither so palatable nor so valuable, pound for pound, as corn silage, though it may be fully equal to some of the other kinds of silage.

Other Materials

Beet pulp, apple pomace, wet brewers' grain, Russian thistle, sugarcane, Napier grass, and weeds of various kinds are also occasionally used for silage with fair to good success.

HARVESTING THE CROP AND FILLING THE SILO

Corn or sorghums for the silo may be cut by hand, by the one-horse, two-row platform cutter (fig. 2), or by the corn harvester and binder. Hand cutting is practiced on farms where the quantity to be cut is too small to justify the purchase of a harvester and when the corn is down or in such position as to preclude the successful use of the platform cutter or the corn harvester. Of the three methods, the Nebraska Agricultural Experiment Station found that, all things considered, the corn harvester constituted the most satisfactory, although the cost per acre was the lowest when the platform cutter was used. In case only a small quantity is to be harvested on each farm, several

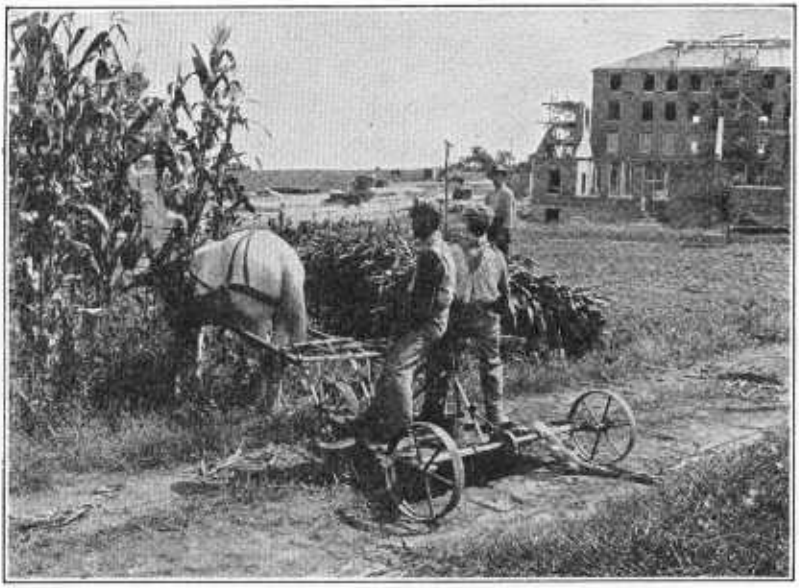

FIGURE 2.—The platform cutter is adapted for use where only a small quantity of silage is to be made.

farmers may well cooperate in the purchase of a harvester rather than to do the work by hand.

When the corn harvester is used, the bundles should be made rather small. While this takes more twine, the extra expense is more than offset by the ease of handling the bundles and feeding them into the silage cutter. The harvester should not get so far ahead of the haulers that the corn will lose any considerable amount of moisture before it reaches the cutter.

A bundle elevator attached to the corn harvester (fig. 3) in place of the bundle carrier is a great saver of labor; it delivers the bundles to a wagon or truck driven alongside the harvester and eliminates the hardest part of the silo-filling work. A load of 2 tons can be put on in 15 minutes. The need of more power to pull the harvester when the elevator is used, and the need of steady power make the use of a tractor desirable.

Hay and pasture crops and those seeded in drills or broadcast are usually cut with a mower, raked into windrows with either a side-

delivery or dump rake, and then loaded on the wagons by hand or with a hay loader (fig. 4). Green crops often are not handled satisfactorily with the ordinary farm machinery. The rakes pass over much of the material, and the loader fails to pick the windrows up clean. Hay loaders must be built for heavy duty. The use of a windrower attachment on the cutter bar of the mower saves the labor of raking and also lessens the chances of stones being elevated onto the wagon or truck along with the green material. There are now machines on the market which will mow and elevate green crops onto a wagon or truck satisfactorily. They are tractor-drawn and are operated with a power take-off.

Hauling to the Cutter

Ordinarily the corn is hauled to the cutter on a common, flat hayrack. It is best to have this rack mounted on a low-wheeled wagon, even when used in connection with a harvester and elevator. Of

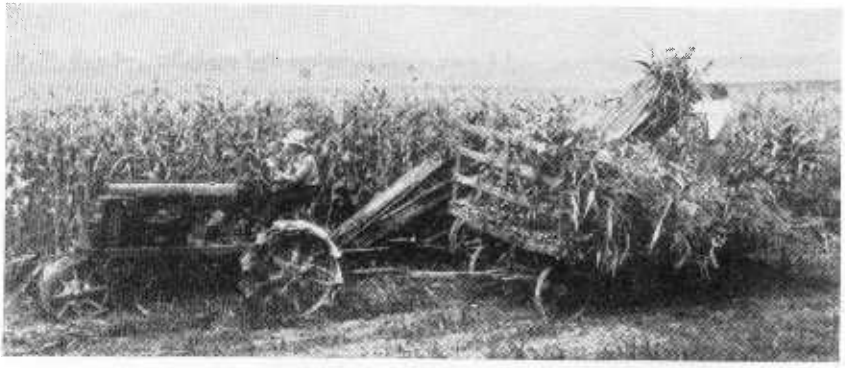

FIGURE 3.—Using a corn binder and bundle elevator.

course, when the loading is done by hand a low-wheeled wagon is preferable to a high-wheeled one.

If few teams are available and the haul is long, the load should be as large as possible. With plenty of teams and a short haul the loads should be smaller, thus saving the labor of high lifting in loading and facilitating the work of unloading.

Cutting the Silage

A number of satisfactory silage cutters are on the market. The chief feature to be considered in a cutter is whether it is strongly made and will handle all kinds of forage crops. It should be so designed that the knives can be changed or adjusted quickly and easily. In order to avoid clogging as well as the use of too much power it is important that the cutter be kept in good order and properly adjusted. Common faults are dull knives, rounded shear plates, too much clearance between the knives and the shear plate, worn fan plates, and improperly adjusted fan-wheel housing. The cutter should be run at the speed recommended by the manufacturers; higher speeds are hazardous.

The usual length of cutting varies from one-fourth of an inch to 1 inch. The latter is too long, as the pieces do not pack so closely in the

silo and the silage is not so completely consumed in feeding as when cut in the shorter lengths. On the other hand, the longer the pieces are the more rapidly the corn can be run through the cutter. Probably most silage is now cut into pieces not over half an inch long. All of the hay and small-grain crops should be cut as fine as possible.

Elevating the Silage

The blower pipe should be as nearly perpendicular as possible (fig. 5) to reduce to the minimum the friction of the cut corn on the inside of the pipe and thus lessen the danger of clogging. If the cutter cannot be placed close to the silo, it is well to keep the blower pipe nearly vertical but to extend it high enough so that the cut corn from the top of the pipe will run into the silo at an angle of about 45°. Horizontal pipes are especially liable to clog if the corn is wet or if it is fed into the cutter rapidly.

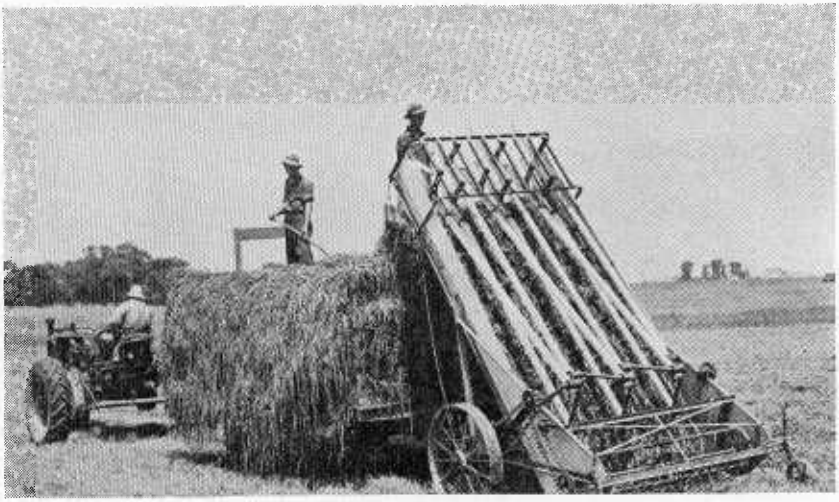

FIGURE 4.—Hay loaders must be specially built to handle green crops.

Trench silos can be filled without any elevating mechanism. The use of a cutter without a blower will save power, but a distributor pipe cannot be used as in figure 6 and more labor must be expended in the silo. Corn and sorghum have been siloed successfully in trench silos without chopping, but this method usually is not advised, except in cases where only a few tons are to be siloed, because of the greater likelihood of spoilage, the greater waste in feeding, and the increased difficulty of removing the silage from the trench.

Power Required [2]

The power required to run the cutter depends upon the kind and condition of material, height of silo, speed of cutter, sharpness of knives, rate of feeding, area of throat, adjustment of shear plate and knives, and closeness with which blower lugs fit the housing.

[2] This discussion was contributed by H. L. Garver and W. R. Humphries, Bureau of Agricultural Chemistry and Engineering, U. S. Department of Agriculture.

In most cases a tractor furnishes the driving power, but occasionally an electric motor is used. Most operators recommend a motor of at least 7½ horsepower for a cutter of 12- to 16-inch widths and silos 40 feet high or less. Inasmuch as the gasoline engine has little or no reserve power above its rating, an engine of ⅓ to ½ greater horsepower rating than that of an electric motor is required.

The speed at which the cutter operates, particularly the flywheel type, is an important factor in determining the power required. A cutter fan 30 inches in diameter will elevate corn silage into a 50-foot silo at around 700 revolutions per minute (peripheral [3] speed 5,500 feet per minute). Larger fans will require lower speeds; for example, a fan of 40-inch diameter would need to operate at around 525 revolutions per minute. The power requirement increases very rapidly with increases in speed, but the rate of cutting varies only in direct

FIGURE 5.—The usual method of chopping corn for the silo.

proportion to the speed; that is, if the speed of the cutter is increased from 350 to 700 revolutions per minute, the power required may increase 5 or 6 times. For example, if a cutter may be driven with a 5-horsepower motor at 350 revolutions per minute, then 30 to 35 horsepower may be required at 700 revolutions per minute while the rate of cutting is merely doubled. Therefore if the blower is an integral part of the cutter it is not economical to operate the cutter at a speed faster than is necessary to keep a crew busy of a size consistent with the amount of silage to be cut.

Packing the Silage

The usual practice is to have at least one man to distribute and tramp the silage. Unless the material is distributed, the leaves are

[3] Speed at the outside edge of the fan blade.

blown to one side of the silo. Many years' experience shows that tramping can be entirely dispensed with so far as the quality of the silage is concerned, but a silo filled rapidly without tramping does not hold quite so much. Experiments show also that if the corn is put in the silo at the proper stage of maturity, distributing the silage is unnecessary for perfect preservation. However, in feeding out silage which has not been distributed it is desirable to take a layer off the entire top of the silage at each feeding; otherwise a batch of silage may contain a preponderance of either leaves or the heavier constituents of the corn plant, as the ear and grain. In packing trench

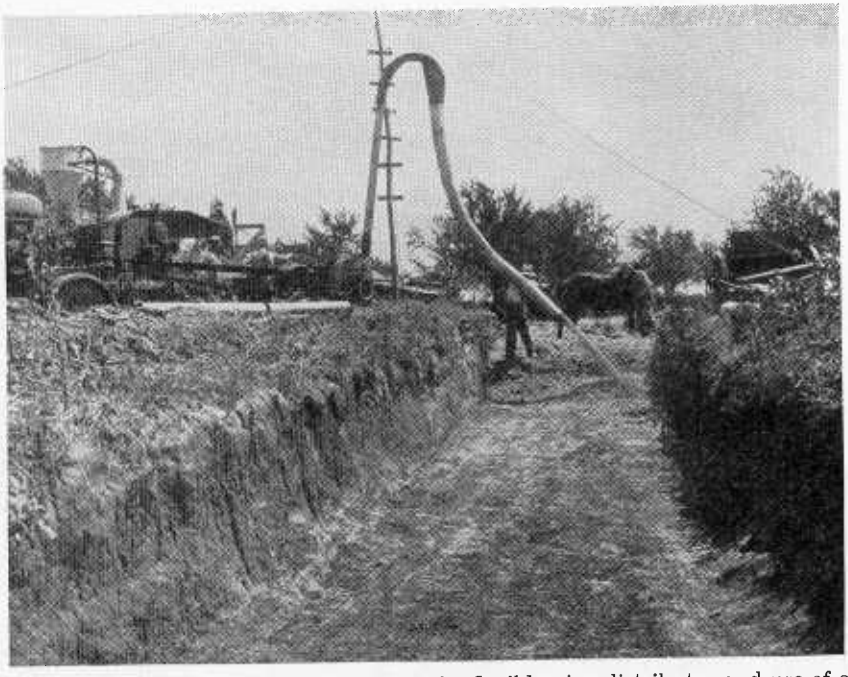

FIGURE 6.—Filling a trench silo. Note the flexible pipe distributor and use of a horse for packing.

silage livestock can be driven back and forth over the chopped material or a tractor of either the wheel or crawler type can be used.

Chopped grasses and legumes tend to hang together more than chopped corn. If the material in the silo settles toward the side that is packed the least, just as a hay stack may settle unevenly, the silage draws away from one side of the silo at the top admitting air and permitting more or less extensive spoilage. The uniform packing of grass or legume silage is important for this reason. Furthermore, such silage normally shrinks away from the sides at the top more than corn or sorghum, and special attention should be given to packing the top. In view of the fact that the silage settles more in the middle than at the sides, it is thought that keeping the center higher than the sides while filling the upper part of the silo may lessen the extent to which the silage will draw away from the sides at the top.

Of various contrivances used for distributing the cut material a metal pipe put together loosely in sections is commonly recommended.

The cut corn from the blower passes down the pipe into the silo, and the pipe, being flexible (fig. 7), can be swung to place the material anywhere in the silo. With this contrivance, handling the material with a fork is unnecessary and one man can easily do the work of two. Very little loose material flies about in the silo, and the work is cleaner. As the silage rises in the silo the distributor pipe can readily be shortened by taking off successive sections.

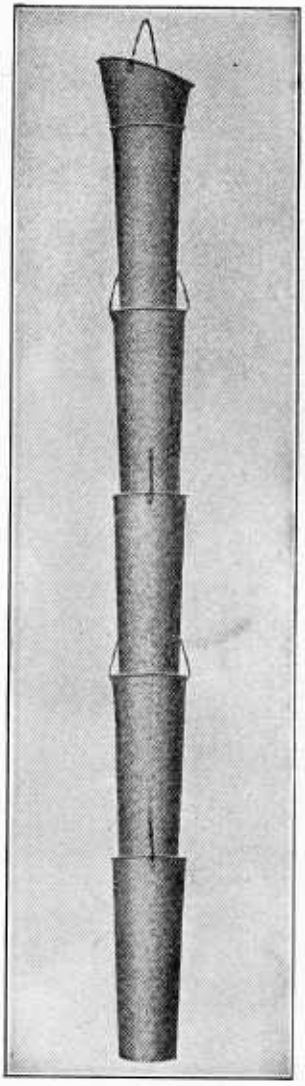

FIGURE 7.—Joined-pipe silage distributor.

One of the products of silage fermentation is carbon dioxide. This gas is heavier than air and for this reason tends to displace the air in the silo above the surface of the silage. If there are no doors or other openings near the top surface of the silage to permit the carbon dioxide to flow off, it may collect on top of the silage. As this gas will not support respiration, a person entering the silo may be overcome from lack of oxygen. Before going into a partly filled silo early in the morning during silo-filling operations, it is best to run the blower a few minutes.

Adding Water

The addition of water to have a moist silage is not of as much importance as was formerly believed. Years ago the practice was to cut silage in about 1-inch lengths. When the corn or other kind of crop is chopped as coarsely as this it does not pack well and force out the air unless the moisture content is high, and even then does not exclude the air so completely as if chopped in short lengths. Recent investigations have shown that low-moisture silages are more palatable than high-moisture silages and that if the air can be excluded by using a tight silo and by fine chopping there is no advantage in adding water. Many wooden silos, however, on standing empty during the summer will shrink and show cracks. When such a silo is filled, the silage must be moist enough to swell the wood and thus close the cracks. Also, merely setting the cutter to chop in short lengths will not insure fine cutting unless the knives are sharp and properly adjusted. Therefore, under most conditions it is safer to add water if the crop has a very low moisture content. This can be done by running a stream of water in the blower or by sprinkling water over the chopped material as it falls in the silo. If the addition of water is deferred until filling is completed, it will flow through the silage in channels and the whole mass may not be moistened.

Field-Chopping Method of Making Silage

The field-chopping method of silo filling has been used to some extent for about 20 years. The standing corn is both harvested and chopped by a machine drawn by a tractor and operated by means of power from the tractor (fig. 8). The cut corn is delivered to a wagon box drawn alongside. It is then hauled to the silo and pushed off into a blower which elevates it into the silo (fig. 9). With a trench or pit silo the material can be dumped directly into the silo. This method of making silage is the easiest known. It is about as rapid and approximately the same size of crew is required as with a harvester and bundle elevator. It is easier because the labor of placing the bundles on the wagon is saved and because pushing the cut material into the blower is easier than throwing the corn bundles into the cut-

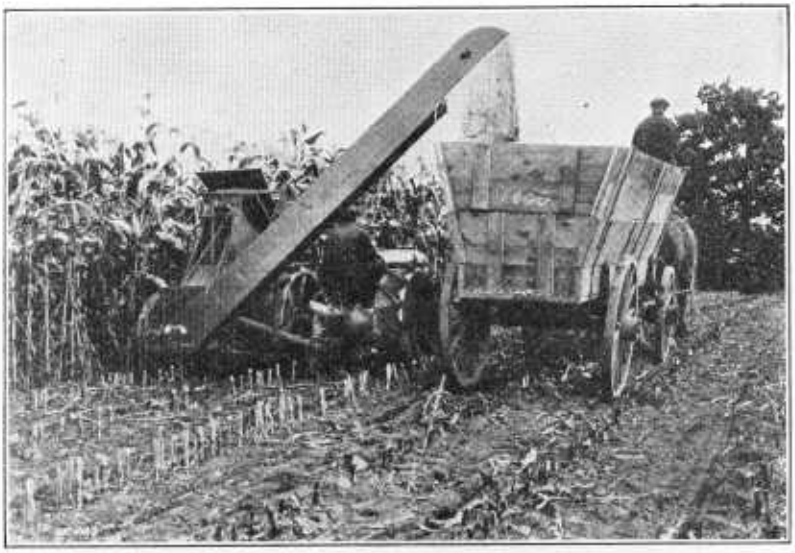

FIGURE 8.—Harvesting the corn by the field-chopping method. (Courtesy of Central Experiment Farm, Ottawa, Canada.)

ter. Also, this outfit may operate successfully on softer ground than will the harvester and bundle elevator because its mechanism is operated by power from the tractor. A disadvantage of the field-chopping system is that corn if blown down must be harvested by hand, and then an ordinary silage cutter must be used. Another disadvantage is the greater cost of this outfit as compared with that of a corn harvester and silage cutter.

Protection of the Top From Time of Filling to Feeding

In tower silos all kinds of silage, but especially that made from the hay crops, tends to shrink away from the walls at the top. This admits air and if unchecked will lead to considerable spoilage. This spoilage can be lessened by filling in each week the opened space at the wall and then tramping thoroughly. Unless some such precautions are taken it will likely be found after a few months that the

spoilage has extended down the sides 4 or 5 feet or more. Formerly it was a common practice to cover the silage with some material such as dirt or chopped straw to prevent the top layer from spoiling. At present the covering, when there is one, usually is a layer of corn from which the ears were removed before chopping. This chopped material, consisting of the heavy green stalks, packs much better and excludes the air more effectually than straw even if chopped and wetted. Chopped weeds or other green materials of little or no feeding value are sometimes used. If the filling of a silo is interrupted for more than 2 days, the top layer will spoil. This spoiled material can be thrown off and used later to put on top of the silage. The top should always be thoroughly tramped and, if dry, should be wetted down. Another method which is used to some extent, especially with silage made from the hay crops, is to cover the top carefully with tar

FIGURE 9.—Transferring to the silo the corn cut by the field-chopping method. (Courtesy of Central Experiment Farm, Ottawa, Canada.)

paper and then put another load or two of heavy green material on top of the paper. It is important that the paper fit closely against the walls. Whenever possible it is better to begin feeding from the silo within a few weeks after it is filled, in order to keep the spoilage on top to a minimum.

In trench silos the material should be piled high enough above the ground level so that after settling is completed, rain and drainage water will flow away from the trench rather than into it. The silage is usually covered first with chopped hay or straw, then with several inches to a foot of dirt. Wetting the sides of the trench before it is filled and wetting the straw and dirt covering will help to prevent spoilage.

It should be emphasized that if wilting of the hay crops is practiced in order to save the expense of acids or molasses, the top 2 or 3 feet of silage in the tower silo should be the heaviest, greenest material available. This is for the purpose of providing an air seal.

Removal of Silage From the Silo

The silage in tower silos should be removed in even layers and the entire top should be kept level. Any spoiled material found around the wall should be removed every day or two rather than allowed to remain, as removal of only the good silage from the middle exposes the silage around the wall more fully and further increases the spoilage. The aim should be to expose as little of the silage as possible and to feed it rapidly enough to prevent heating and spoiling.

Trench silos are emptied by removing the silage in vertical layers from the end of the silo (fig. 10). In many cases the truck or wagon is backed into the trench for easy loading and the silage is hauled to

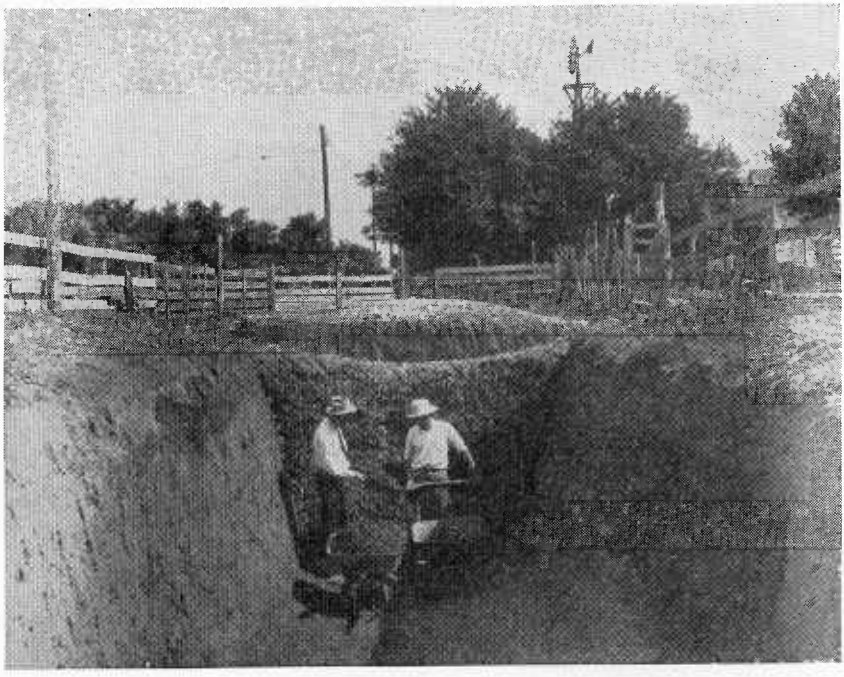

FIGURE 10.—Removing silage from a trench.

bunks for feeding. When the quantity to be removed daily is small, or the silage is to be fed in a barn which the truck or wagon cannot enter, it may be more convenient to use a wheelbarrow, cart, or a litter carrier.

FEEDING VALUE OF SILAGE

Silage may be the principal source of forage for the winter feeding of cattle in regions where the making of good hay is uncertain and where the hay crops yield very much less than the silage crops. It has a feeding value 30 to 40 percent as much as that of good hay. Only rarely, however, is it used to the entire exclusion of hay, straw, or stover.

The outstanding characteristics of silage are its palatability, its consumption without waste, and its carotene content. The amount of carotene in properly made corn silage may be as much as in the

green crop from which the silage was made, even after more than a year of storage. The loss of carotene then would be the same as the loss in weight of silage. This will rarely be less than 10 percent and in the case of long storage may run as much as 25 percent. In the case of the hay crops the carotene loss appears to be higher, averaging about 25 percent. Because of its high carotene content silage is particularly valuable to supplement grain and low-quality hay in the ration. With some classes of livestock the main purpose of using silage may be to provide carotene.

Silage made from corn, sorghums, small grains, or grasses contains insufficient protein and mineral matter for growth and milk production, and must be supplemented with some feed or feeds that will supply these deficiencies. Legume hay is an especially good one for this purpose, because it is relatively high in both protein and calcium. Also it has been found that livestock will eat more nutrients on a ration of silage and legume hay than they will when fed solely on silage. While a ration of silage and hay is suitable for maintenance of dry cows or for the maintenance and growth of yearling cattle intended for breeding purposes, a more concentrated ration is required for heavy yields of milk or rapid growth. In case a phosphorus deficiency is suspected in the rations, it is advisable to add some wheat bran or one of the oil meals or steamed bonemeal; and if no legume hay or legume silage is included in the ration it is well to feed some ground limestone or bonemeal to provide the necessary calcium.

Composition

The chemical composition and the nutritive value of silage vary according to the crop put in the silo, the degree of maturity of the crop, and other factors (table 3). In general the composition is similar to that of the green crop from which the silage is made. Present information shows that there are no consistent or significant differences in the digestible nutrients of the dry matter of a crop (see the figures in the last column of table 3), whether the crop is in the green state or whether it is made into silage, hay, or fodder.

Silages vary tremendously in their content of moisture, and their value cannot well be estimated without taking the moisture into consideration. The quantity of nutrients depends directly upon the content of dry matter. For example, if a silage made from any certain crop contains, say, 40 percent more dry matter than another silage made from the same crop, then the digestible nutrient content will likewise be approximately 40 percent greater. One hundred tons of silage containing 25 percent dry matter may be no more valuable than 70 tons containing 35 percent dry matter. The relative feeding values of silage and hay made from the same crop can be estimated by comparing the amounts of dry matter contained. A high quality of hay containing 90 percent dry matter is worth approximately 3 times as much as the same weight of silage containing 30 percent dry matter.

Legume silage, if properly made, has a composition that indicates a feeding value of the dry matter comparable to that of good hay and of the green crop from which it is made (table 3). Feeding experiments point to the same conclusion. There is still some question, however, as to how well livestock will thrive on legume silage alone, especially high-moisture, high-acid silage. It will be better to feed some dry

material, as hay or stover, along with high-moisture legume silage, particularly since certain experiments indicate that a ration of medium- to high-moisture legume silage is improved by the addition of either dry hay or corn silage.

TABLE 3.—*Composition and digestible nutrients of certain forages—green, as silage, and dried* [1]

Forage crop	Composition of the forage						Digestible crude protein in the forage	Total digestible nutrients in the forage	Total digestible nutrients in the dry matter
	Moisture	Ash	Crude protein	Ether extract (fat)	Crude fiber	Nitrogen-free extract (sugars, starches, etc.)			
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Percent*	*Percent*	*Percent*	*Percent*
Alfalfa, in bloom, green	77.2	1.8	3.2	0.6	7.8	9.4	2.4	12.9	56.7
Alfalfa silage	68.9	2.7	5.7	1.0	8.8	12.9	4.0	18.8	60.6
Alfalfa hay	7.2	8.0	15.4	1.6	30.3	37.5	10.8	52.3	56.4
Red clover, in bloom, green	70.8	2.1	4.4	1.1	8.1	13.5	2.9	19.4	66.4
Red clover silage	72.0	2.6	4.2	1.2	8.4	11.6	1.3	12.1	43.0
Red clover hay	7.0	10.0	16.1	2.6	23.6	40.7	9.7	49.5	53.2
Soybeans, green	73.9	2.9	4.0	1.1	7.6	10.5	3.2	16.0	61.1
Soybean silage	75.6	2.6	2.4	.8	9.6	9.0	1.6	13.1	53.5
Soybean hay	8.4	8.9	15.8	3.8	24.3	38.8	11.2	55.6	60.7
Timothy, in bloom, green	61.6	2.1	3.1	1.2	11.8	20.2	1.5	22.9	59.5
Timothy silage	60.3	2.8	4.4	1.4	13.0	18.0	2.3	23.8	59.8
Timothy hay	7.1	5.8	7.5	2.9	30.2	46.5	3.5	52.5	56.5
Corn fodder, dent, green	73.4	1.5	2.0	.9	6.7	15.5	1.3	19.3	72.7
Corn silage	70.9	1.4	2.4	.9	6.9	17.5	1.1	19.8	67.9
Corn fodder, dry	11.8	5.8	7.4	2.4	23.0	49.6	3.4	55.3	62.7
Sorgo, green	77.3	1.3	1.5	1.0	6.2	12.7	.6	15.3	67.2
Sorgo, silage	74.7	1.4	1.6	1.0	6.9	14.4	.4	15.3	60.5
Sorgo fodder, dry	11.6	6.0	5.3	2.4	26.0	48.7	3.3	58.2	65.8

[1] Compiled in the Division of Animal Nutrition, Bureau of Animal Industry.

Rate of Feeding

When silage is exposed to the air in warm weather it spoils quickly. For this reason a uniform layer would be removed from the top every day. In summer this layer should be not less than 3 inches thick, but during cold weather feeding may be as slow as desired. It has been noted that when the removal of silage is discontinued for as much as a month in cold weather the exposed surface may remain in perfect condition except for some slight drying out.

Feeding Frozen Silage

Frozen silage must be thawed before being used; it should then be fed immediately, before decomposition sets in. No harm will result from feeding it after it is thawed, nor is the nutritive value known to be changed in any way.

SILAGE FOR DAIRY CATTLE

Silage has been found to be particularly well adapted as a feed for dairy cows, and in consequence silos are more numerous on farms devoted to dairying than on any other kind of farms. In many sections silage has come to be the dairy farmer's main reliance for winter roughage.

RATIONS

A good rule to follow in the feeding of corn silage is to allow each cow about 3 pounds of silage a day for each 100 pounds of live weight. For example, give an 800-pound cow 24 pounds of silage, a 1,200-pound cow 36 pounds of silage, and so on. Along with this give the cow all the hay that she will eat. The quantity of grain to feed depends on a number of factors, chief of which are quantity and quality of milk yielded and kind and quality of hay fed. The quantity of silage stated above and all the good legume hay the cow will eat twice a day will support a milk yield of from 10 to 16 pounds, depending on the richness of the milk. Consequently, cows giving no more than these quantities require no grain. For the production of milk above these quantities the nutrients must be provided in the grain. About 0.4 pound of grain is required to provide the nutrients for the production of 1 pound of milk testing 3.5 percent or less butterfat, 0.5 pound for milk of medium richness testing 4.5 percent, and about 0.6 pound for milk testing more than 5.5 percent. For example, if a cow is giving 25 pounds of milk testing more than 5.5 percent, 10 pounds of this will be provided for by the roughage, whereas 15 pounds must be provided for by the grain. The quantity of grain needed, therefore, is 15×0.6, or 9 pounds. If a cow is giving 36 pounds of milk testing 3.5 percent or less, 20 pounds must be provided for by the grain. The quantity of grain needed for this cow, therefore, is 20×0.4, or 8 pounds. Coarse or poorly cured hay is not consumed in such quantities as good legume hay. Consequently, when inferior hay is fed the grain allowance must be increased.[4]

Some Recent Feeding Experiments

At the Ohio and Iowa Agricultural Experiment Stations corn silage or corn and soybean silage was fed to cows for periods of 5 months. No hay whatever was fed, but the silage was supplemented with minerals and with a high-protein concentrate. The cows remained in good health and produced at a normal rate. Similar results were obtained at the Beltsville, Md., Research Center.

At the Puyallup, Wash., Experiment Station an experiment has been under way for several years in which either grass hay alone, or grass silage alone, or both hay and silage constitute the ration fed to three groups of cows through the winter period of about 140 days. During the pasture season all three groups are pastured. No grain has been fed at any time during the experiment. The results show no significant differences between the three rations in respect to either health or production.

At the Huntley, Mont., Experiment Station grass silage made from immature pasture herbage was fed as the sole ration to four cows for a period of 1 year and hay made from similar herbage was fed to another group of four cows. The results in general were more favorable to the hay ration; the cows fed grass hay consumed a little more dry matter, produced a little more milk, and had less breeding trouble than those on grass silage.

[4] This subject is discussed more fully in Farmers' Bulletin 1626, "Feeding Dairy Cows."

TIME TO FEED

Corn silage usually affects the flavor and odor of milk, according to results of experiments described in United States Department of Agriculture Bulletin No. 1097, and other silages will probably have a similar effect. The influence may be somewhat more pronounced with some silages than with others. All silages should be fed after, rather than before, milking. In case the silage has a rank odor it is important that the milking stable be relatively free of these odors at milking time in order to avoid having them absorbed by the milk.

SILAGE FOR CALVES, BULLS, AND DRY COWS

Although silage has been fed successfully to vigorous young calves as soon as they would eat it and in as large quantities as they would consume, there is some evidence that it should be omitted from the ration until the danger of serious digestive disturbances is past, say 60 or 90 days, after which it may be fed safely in quantities up to the capacity of the calf. Yearling heifers consume about half as much as mature stock, that is, from 12 to 24 pounds a day if they are well-grown. When the silage is supplemented with some good legume hay, no grain is required to keep the yearlings in a thrifty growing condition.

Some breeders of dairy stock think that a large allowance of silage is detrimental to the breeding qualities of the bull. Whether this opinion will be upheld or substantiated when carefully investigated remains to be determined. Probably it is best to limit the allowance to about 12 or 15 pounds a day for each 1,000 pounds of live weight. When fed in this quantity, silage is thought to be a perfectly safe feed for bulls. It should be supplemented with hay, of course, and with grain also, especially in the case of bulls in active service or growing rapidly.

When cows are dry they consume almost as much roughage as when they are producing milk. Silage may well form the principal ingredient of their ration; in fact, with from 25 to 40 pounds of silage and from 5 to 8 pounds a day of clover, soybean, or alfalfa hay, the cows will keep in good flesh and even gain in weight. Dry cows in thin flesh should always receive some grain.

SILAGE FOR SUMMER FEEDING

One of the most trying seasons of the year for dairy cows is the latter part of summer and early fall. At this season the pastures are often short or dried up, and it is a common mistake of dairymen to let their cows decline in milk flow because of the shortage of feed. Later in the fall it is impossible to restore the milk flow, no matter how well the cows are fed. On good dairy farms the milk flow of the cows is maintained at as high a level as possible, from calving to drying off. It becomes necessary, therefore, to supply some feed in addition to pasture grass. The easiest way to do this is to feed silage, which is cheaper and decidedly more convenient to use than soiling crops. The amount to feed depends on the condition of the pastures, varying all the way from 10 pounds a day to a full (winter) feed. The difficulty in the use of silage as a supplement during the summer months is in feeding it rapidly enough and with sufficient regularity to prevent spoilage.

Early hay crops or surplus spring pasturage may be made into silage advantageously, provided weather conditions are unfavorable for curing such materials into hay. The silage can then be fed as a supplement to pastures. One advantage of grass silage used in this way is that the same silo used for storing winter feed can also be used for storing summer feed.

SILAGE FOR BEEF CATTLE

Beef cattle are perhaps capable of making a greater utilization of coarse roughages than most other kinds of domestic animals. Yet cattle frequently eat only the leaves and fine stems of many mature forages. In the case of some varieties of soybeans and of corn fodder made from rather mature plants, the percentage of refused feed may vary from 25 to 50 percent. When such forages are made into silage and fed to cattle, there will be very little waste, provided the silage is of good quality. It has been demonstrated by State experiment stations that silage made of sorgo, sorghum, or corn from a given acreage will feed fully twice as many cattle as the fodder produced from a similar area.

Silage has its greatest usefulness as the main feed, so far as wintering rations for beef cattle are concerned. This applies particularly to the breeding herd and to stocker or feeder cattle. In fattening rations well-made silage may serve chiefly as a source of vitamins, minerals, and sometimes as a source of good-quality protein. In many sections of the Corn Belt it is used rather extensively in steer-fattening rations, but the quantity fed in the ration is usually somewhat limited. The place of silage in beef-cattle feeding is quite well known in the Corn Belt and sorghum-producing areas. In other areas where these popular silage crops are not grown, it may be possible to convert hay and other forage crops into silage. Such a practice is adaptable to many areas in the South where it is almost impossible to cure crops as hay or fodder, due to the humid climate. The making of silage from legumes and grasses is no longer experimental and should be adapted to the Southeastern States and the Gulf coast region, where the harvesting seasons for hay are usually marked by frequent rains. In the feeding of grass or legume silage, the fact should not be overlooked that the protein content is much higher than it is in corn silage. Alfalfa silage, for example, will supply approximately twice as much protein as an equal amount of corn silage. The use of grass silage will therefore make possible a reduction in the quantity of protein-rich concentrates usually fed with silage.

Since silage will keep indefinitely without appreciable deterioration, if it does not dry out or come in contact with the air, it affords good insurance in case of drought.

The quantity of silage required in a ration for beef cattle depends somewhat on the water content, which is variable, and the quantity of grain in the silage when it is made. Since ordinarily 100 pounds of silage contains approximately 70 pounds of water and only 30 pounds of dry matter, and 100 pounds of hay which has gone through the sweat contains nearly 90 pounds of dry matter, it takes approximately 3 pounds of silage to equal 1 pound of hay. This is a safe rule to follow in estimating the quantity of silage to feed when one knows the hay requirements. With respect to the percentage of protein, crude fiber, starch, sugar, and fat in the dry matter, corn silage is very similar to

the hays made from plants such as timothy, Sudan grass, and the wild prairie grasses. The chief difference is that the dry matter of corn silage has less crude fiber and more starch than the hay on account of the ears, which make up nearly 50 percent of the weight of the mature corn plant. Therefore, as proved in practice, one may feed 3 to 6 pounds of corn silage per 100 pounds of live weight of cattle for the same purpose that one would feed 1 to 2 pounds of grass hay per 100 pounds live weight, with about the same results.

SILAGE FOR WINTERING BEEF CATTLE

As indicated heretofore, silage has its greatest use in wintering rations for breeding, feeder, and stocker beef cattle. As much as 40 pounds of silage with straw and small quantities of protein concentrates are fed daily to beef cows carrying or nursing calves. For dry cows, not with calf, it is a common practice to feed about 25 pounds of silage with unlimited straw or stover and a small quantity of protein concentrate.

Breeding bulls are not usually fed as heavy silage rations as cows. Two pounds of silage for each 100 pounds live weight of bull with grain and hay are usually sufficient.

Although it is not likely that young calves getting plenty of milk will eat enough silage to cause any digestive disturbance, it is considered advisable to allow them only small quantities along with other feeds. Particular care should be taken to see that the silage fed to calves is free from mold, as the calf's digestion is easily upset by improper feeding. If calves are to be fed silage, they should be fed only a small quantity at first when about 2 months of age. The silage should be increased very gradually, so that not more than 8 pounds are consumed daily by the time the calf is weaned, at 8 to 9 months of age.

Steers 2 years old or over, or other mature beef cattle, may be wintered almost exclusively on good-quality silage with a small quantity of dry roughage, such as straw or stover. Younger cattle which have to be grown out require some protein, which may be supplied either in the form of a concentrate or as a legume hay. Steers naturally require somewhat less protein than heifers being grown to add to the breeding herd and those which have been bred.

Suggested rations for wintering various classes of beef cattle are listed in table 4.

TABLE 4.—*Suggested rations (containing silage) for various classes of beef cattle*

Class of cattle	Grain [1]	Protein concentrate [2]	Silage	Legume hay	Mixed hay	Straw or stover
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Wintering breeding cows		1.5	40			8
	3		30	6		
Wintering yearling heifers		1	15		10	
	3	1	10	5		5
Wintering yearling steers		1	16			4
Wintering calves			8	10		
Wintering bulls (1,000 pounds live weight)	5	1	20		3	
Fattening steers of—						
1,000 pounds live weight	18	2.5	20		5	
800 pounds live weight	15	2	15		3	
600 pounds live weight	12	1.5	15			3
400 pounds live weight	10	1.5	10		3	

[1] Grain may be corn, barley, wheat, rye, or rice products.
[2] Protein concentrate may be cottonseed, linseed, soybean, velvetbean, or peanut meal or cake.

SILAGE FOR FATTENING BEEF CATTLE

Silage is used in fattening rations most extensively in those areas where the supply of legume hay is more or less limited. Silage is usually associated with straw, grass hay, grain, and a protein-rich meal in fattening rations rather than in those having legume hay (fig. 11). The requirements as regards protein, carbohydrates, minerals, and vitamins for fattening cattle are somewhat different from those for cattle on maintenance and growing rations. More net energy is required in the case of the fattening animal. Hence feeds are included which contain relatively high percentages of readily digestible starch, sugar, and fat. The use of such feeds makes it possible for the animals to store the surplus of nutrients in the form of

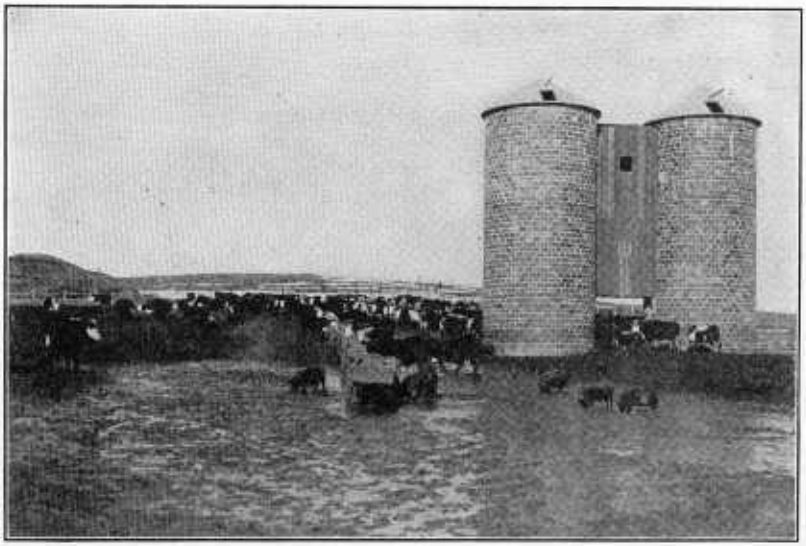

FIGURE 11.—Steers in Corn Belt feed lot being fattened on a ration containing silage. Hogs are an important asset to most feed lots.

increased muscular tissue and deposits of fat. The more rapid the resulting gains in weight, the smaller the proportion of the feed used for maintenance, which tends to reduce the cost of gains.

Therefore, when grain is relatively cheap, the most economical gains are produced by feeding as much of it as the cattle will eat and just enough of the roughages to supply bulk and also minerals and vitamins not adequately available in the concentrates. But when the concentrates are relatively expensive it is more economical to use a larger proportion of the cheaper roughages and feed the cattle over a longer period to reach the same degree of finish.

In considering the use of corn silage to fatten cattle, one should keep in mind that corn silage usually contains almost as much grain as roughage, when calculated on a dry-matter basis. In the Corn Belt the average is approximately 6 bushels per ton.

A 5-year survey in several of the principal cattle-fattening sections of the Corn Belt showed that silage is used much more extensively when grain and other concentrates are high in price than when such

feeds are relatively low in price and that farmers are more favorable toward the use of silage for feeder steers weighing less than 750 pounds than for steers weighing over 750 pounds. This survey also showed that silage is used more extensively in the eastern part of the Corn Belt, where the quantity and quality of the legume hay that can be produced locally from year to year are uncertain factors. In the western part of the Corn Belt, where alfalfa is a particularly dependable crop, silage is not used so extensively in fattening cattle. There was a marked tendency for farmers feeding large numbers of steers and not having enough hay of their own production to use silage rather extensively. Farmers fattening not more than a carload of steers made less extensive use of silage. This emphasizes the value of silage as a dependable source of roughage.

Experiments have shown that a certain quantity of dry roughage should be fed in rations containing silage. Steer-fattening rations containing considerable quantities of silage are shown in table 4.

SILAGE FOR SHEEP

The use of silage in the winter ration of the flock is increasing. Heretofore many sheepmen have been prejudiced against the use of silage, claiming that it caused abortion and losses of breeding stock. It has been proved by different experiment stations in tests with both breeding and feeder lambs that good silage is an economical as well as valuable part of the ration. Where moldy, decomposed, or too acid silage is fed losses occur, but judicious feeding of good-quality silage improves the health and vitality of the flock.

SILAGE FOR THE BREEDING FLOCK

No cheaper or better roughage can be fed the breeding flock than good corn silage, which furnishes the succulence so necessary for the maintenance of the health and vitality of the ewes.

A good quality of silage is very palatable, and quantities ranging from 1 to 5 pounds per head per day have been fed in different feeding trials with good results. The quantity to be fed depends on the class of sheep and the character of the other feeds comprising the ration. As a rule, however, not more than 4 pounds of silage per head per day should be fed, and some hay always should be in the ration.

Silage shows the best results when fed with a good legume hay. The following has been found to be a good ration for the breeding ewe:

	Pounds
Corn silage	3 to 4
Clover or alfalfa hay	2 to 3

Toward the end of the period of pregnancy it is well to add about one-half to 1 pound of grain to the ewe's ration, thus insuring a strong lamb. If the silage contains a fairly large quantity of grain, however, this increase may not be necessary. If the ewes are in extra-good condition at the beginning of winter and do not lamb until the pasture season opens, grain may be dispensed with. Usually earlier lambing and the use of some grain are found to be more profitable, in the latitude of the Corn Belt and the South.

SILAGE FOR LAMBS

In fattening lambs, corn silage not only takes the place of part of the hay and grain but may reduce the cost of grains.

Care must be exercised in starting lambs on silage. If too much is given at the beginning of the feeding period, the lambs will probably go off feed and scour. To prevent this, offer a small quantity at the start and gradually increase the daily allowance until they are on full feed. Lambs weighing from 50 to 60 pounds should consume about 1.5 pounds of silage per head per day when receiving grain and hay in addition. Larger quantities of silage can be fed, but some protein supplement, such as linseed or cottonseed cake, should be added to balance the ration.

A fattening ration for lambs that gave excellent results at the Indiana Agricultural Experiment Station is as follows:

	Pounds
Grain (shelled corn, 7 parts; cottonseed meal, 1 part)	1. 26
Corn silage	1. 40
Clover hay	1. 40

In wintering ewe lambs, silage should form an important part of the ration, and when fed in conjunction with a good legume hay it not only keeps the lambs in good condition but furnished a good growing ration.

SILAGE FOR HORSES AND MULES

Silage is not generally used in horse and mule feeding, but is it a safe feed for either horses or mules if it is of good quality and is carefully fed.

Both horses and mules are peculiarly susceptible to the effects of molds, and under certain conditions varieties of molds are found in silage which are deadly poisons to both of these classes of stock. If the feeder watches the silage carefully as the weather becomes warm, he can soon detect the presence of mold. When mold appears, the feeding should be stopped immediately. Similarly, care should be exercised in the winter feeding of silage so that horses or mules are not allowed to eat frozen silage, because of the danger of colic.

Corn silage is the only kind that so far has met with any degree of favor as a horse or mule feed. Corn which is to be siloed for this purpose should not be cut too green, as sour silage will result, and this may cause colic when fed. Corn for such feed, rather, should be cut when most of the kernels have passed beyond the milk stage.

Silage should not be considered as the principal roughage for horses and mules, but should serve as a partial substitute for hay in the ration. Because of its bulky nature, horses and mules doing hard work should not be fed large quantities, but, owing to its tonic, laxative, and appetizing effects, it is well suited for the maintenance of idle horses and mules, brood mares, and growing stock. The value of silage is greatest, in the case of horses and mules, as a means to carry them through the winter cheaply or to supplement pasture during periods of drought. When used, silage should be introduced gradually into the ration, and the amount fed should generally not exceed from 10 to 15 pounds daily per animal.

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